

## EXPERIMENTAL STUDIES ON VIBRATION CHARACTERISTICS OF LATHE MACHINE TOOL UNDER DIFFERENT CUTTING CONDITIONS

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### ABSTRACT

In this paper the chatter vibrations in metal cuttings on lathe machine is investigated experimentally. Since the dynamic cutting force is strongly influenced by the variations of cutting parameters, the objective of present paper is to consider the variations of cutting speed, feed and depth of cut on the vibrations of cutting process on the lathe machine. By analyzing experimental results it can be concluded that maintaining appropriate cutting parameter play important role in suppressing vibration that are developed during metal cutting process. For each of cutting conditions, the variations of cutting force component (thrust force) as a function of time are obtained numerically and treated as the input excitation for the lathe machine. The measurement of vibration in terms of acceleration by accelerometer is expressed as a function of time.

**KEYWORDS:** Metal Cutting, Accelerometer, Chatter

### INTRODUCTION

Chatter vibrations belong to the class of self-excited vibrations, whose occurrence in metal cutting has a bad influence on surface finish and dimensional accuracy of the work-piece, tool life and even machine life. A significant number of investigations have been done on various mechanisms and characteristics of chatter. The cutting process with variable feed is one of the principles of arising of chatter vibrations. Tobias and Fishwick, et al [4] found the first analytical expression of the dynamic cutting force variation as a function of an incremental variation of the chip-thickness and feed velocity. Kainth et al [1], evolved a theory of steady-state orthogonal cutting by including the influence of both chip-thickness and the rake angle. Nigm et al. [2] considered the variations in the cutting parameters: feed, rake angle and cutting speed on the basis of dimensional analysis. Lin and Weng [5] envisaged the cutting force affected by the variation of shear angle. All these researchers used nonlinear analytical models. Two aspects of the non-linearity of the cutting force are: i) obtaining solutions are difficult and ii) assumptions made in the model may give results far from the real situation. In this paper an experimental model is developed with low cost and accurate devices to measure vibrations that arise in metal cutting operations on the lathe machines. The results obtained are compared with the non linear models developed by other researchers. The paper is organized in the following manner. Section 2 describes the details of experimental setup and the characteristics of various devices used. Section 3 covers the results of vibration of lathe machine tool at cutting zone and discourses the influence parameter on the machine tool vibration. Conclusions are drawn in section 4.

### EXPERIMENTAL SETUP

Figure 1 shows photograph of experimental setup to measure the vibrations and cutting forces. In any cutting process the vibrations on the machine tools is mainly due to the cutting forces arise due to the interaction between cutting

tool and work piece. To study vibrations characteristics on lathe machine tool, an hollow cylindrical work piece and a single point cutting tool are taken .To measure the cutting forces during the cutting operation, a dynamometer is mounted in the tool post. Accelerometer transducers have been used to maser machine tool vibrations nearer to cutting zone places.



Figure 1: Photograph of Experimental Set-up

## RESULTS AND DISCUSSIONS

For experimental studies the following cutting conditions are taken: 1. Engine lathe 2: work piece: mild steel and 26mm, 3: cutting speed range taken : 450-1120 RPM, 4: cutting tool: HSS SPCT, 5: Depth of cut range: 0.2-0.5mm , 6: feed range: 0.045-0.063 mm/rev, 7: Dynamometer and 8: Accelerometer transducer. Cutting parameters used in the process have been grouped into 12 combinations and in each case the cutting forces and corresponding vibrations measured simultaneously .The parameters are measured over a period of 50-60 seconds in each case. Figures 1 to 12 shows the experimental measured results of cutting forces and vibrations in a time span of 50 seconds under 12 cases.

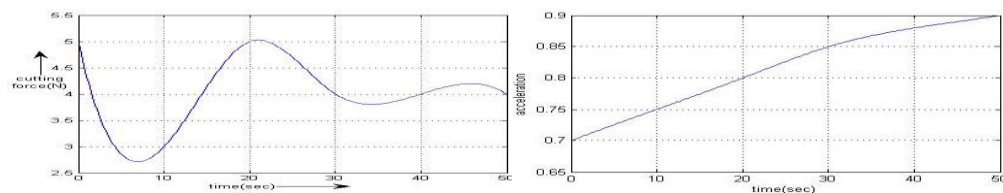


Figure 2: (I) Cutting Force (II) Acceleration (N=450 Rpm, T=0.045, F=0.2 Mm)

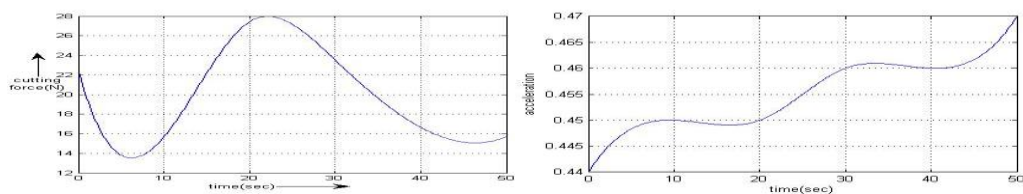


Figure 3: (I) Cutting Force (II) Acceleration (N=450 Rpm, T=0.045, F=0.5 Mm)

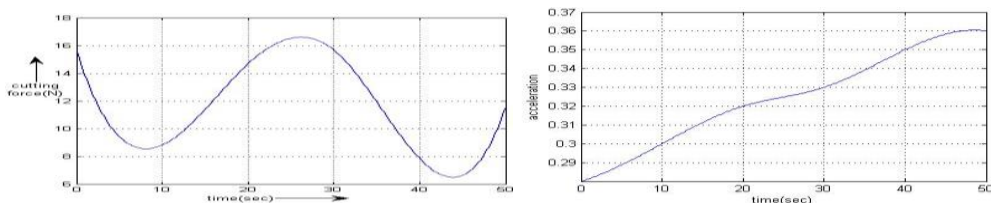


Figure 4: (I) Cutting Force (II) Acceleration (N=450 Rpm, T=0.063, F=0.2 Mm)

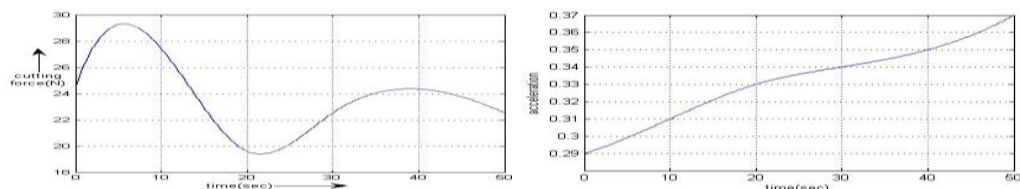


Figure 5: (I) Cutting Force (II) Acceleration (N=450 Rpm, T=0.063, F=0.5 Mm)

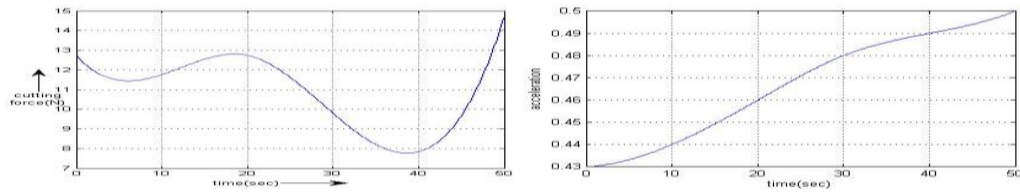


Figure 6: (I) Cutting Force (II) Acceleration (N=710 Rpm, T=0.045, F=0.2 Mm)

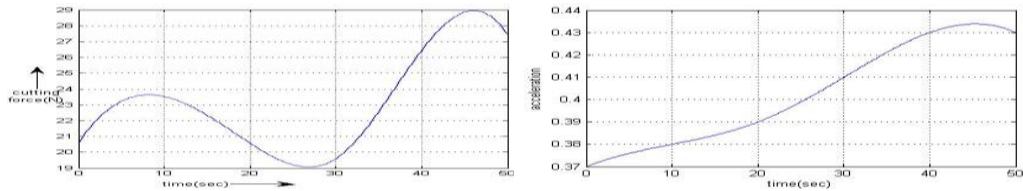


Figure 7: (I) Cutting Force (II) Acceleration (N=710 Rpm, T=0.045, F=0.5 Mm)

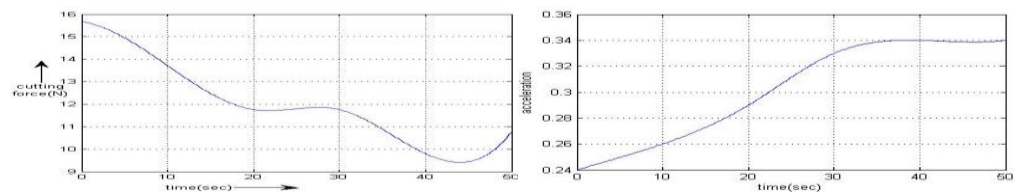


Figure 8: (I) Cutting Force (II) Acceleration (N=710 Rpm, T=0.063, F=0.2 Mm)

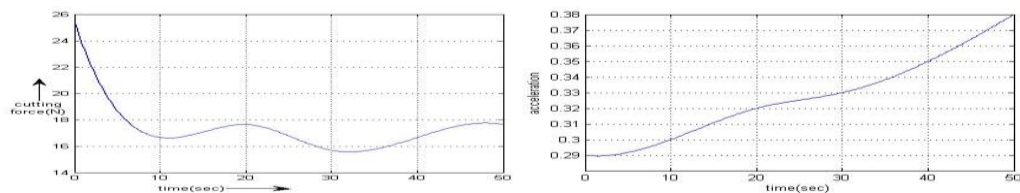


Figure 9: (I) Cutting Force (II) Acceleration (N=710 Rpm, T=0.063, F=0.5 Mm)

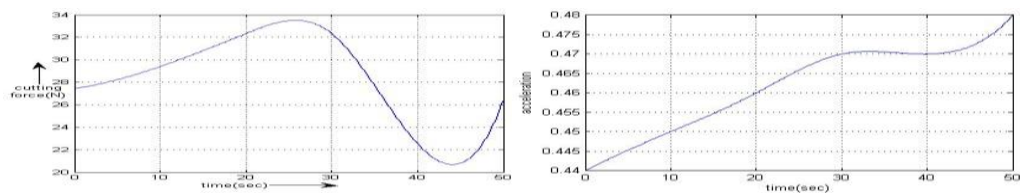


Figure 10: (I) Cutting Force (II) Acceleration (N=1120 Rpm, T=0.045, F=0.2 Mm)

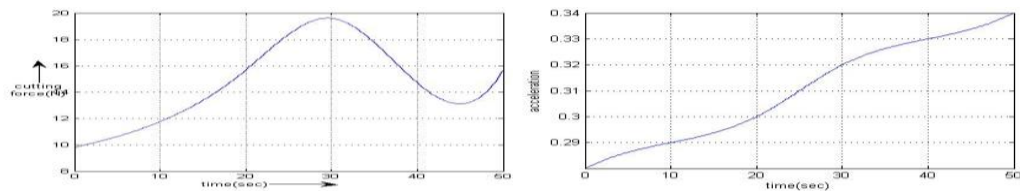


Figure 11: (I) Cutting Force (II) Acceleration (N=1120 Rpm, T=0.045, F=0.5 Mm)

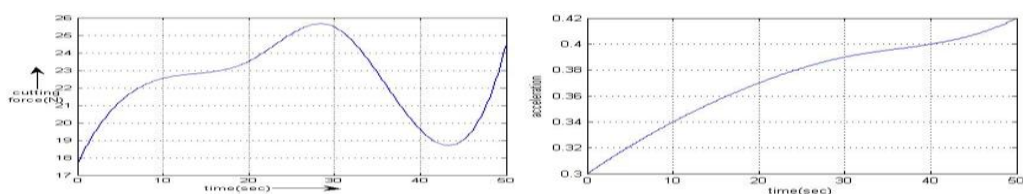
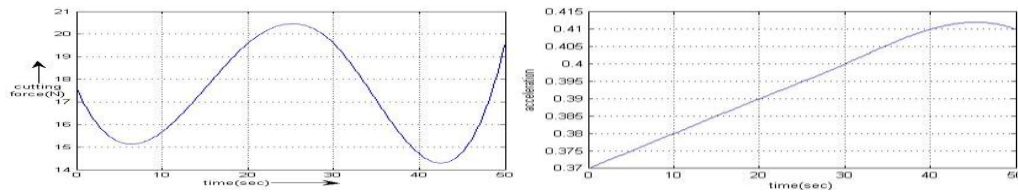


Figure 12: (I) Cutting Force (II) Acceleration (N=1120 Rpm, T=0.063, F=0.2 Mm)



**Figure 13: (I) Cutting Force (II) Acceleration (N=1120 Rpm, T=0.063, F=0.5 Mm)**

From graphs shown Figures 1 to 12, it is observed that the cutting force varies non linearly in all cases except the conditions (N=710 rpm, t=0.063, f=0.5 mm) and (N=710 rpm, t=0.063, f=0.5 mm) and the machine tool vibrations increased in all cases. In all situation, the magnitude of cutting force acting on the machine tool as excitation force varied 5N to 30N with a maximum two cross over frequencies. The maximum amplitude of machine tool is observed as  $09\text{mm/s}^2$ .

## CONCLUSIONS

The experiment mainly consist of a dynamo meter to measure cutting force in two directions and accelerometer to measure the vibration generated in the cutting process. The experiment has been conducted by taking the same cutting parameters that are generally used in the cutting operation of mild steel material. The cutting condition in the experiment an orthogonal and the range of the chatter on lathe is limited less than  $10\text{mm/s}^2$ . The dynamometer is used to measure the cutting force in the Z-direction in a time interval of 1 second. The fluctuations values that represent the cutting forces are extracted for a period of 50 seconds with the critical observation. The pattern of the fluctuation cutting forces is determined and it is an exciting force for the machine tool vibration system. Three locations haven identified at cutting Zone and vibrations are measured with Accelerometer. It id found from the studies that the amplitude of machine tool is observed varies from  $0.25\text{mm/s}^2$  to  $0.9\text{mm/s}^2$ .

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